Automated Derivation of Complex System Constraints from User Requirements

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Automated Derivation of Complex System Constraints from User Requirements

- Background
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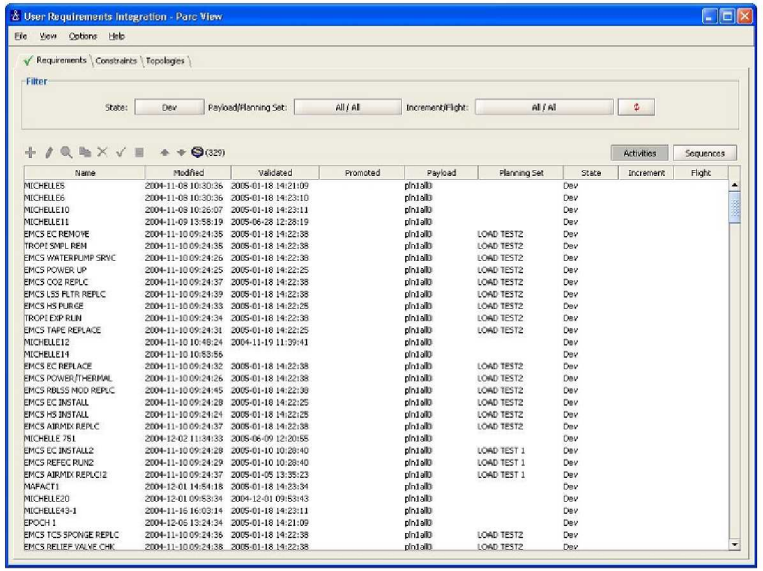
- Operations Concept
- Payload Planning System (PPS)
- Conclusions



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Background

- The Payload Operations Integration Center (POIC) located at the Marshall Space Flight Center has the responsibility of integrating US payload science requirements for the International Space Station (ISS).
- All payload operations must request ISS system resources so that the resource usage will be included in the ISS on-board execution timelines. The scheduling of resources and building of the timeline is performed using the Consolidated Planning System (CPS). The ISS resources are quite complex due to the large number of components that must be accounted for.
- The planners at the POIC simplify the process for Payload Developers (PD) by providing the PDs with a application that has the basic functionality PDs need as well as list of simplified resources in the User Requirements Collection (URC) application.
- The planners maintained a mapping of the URC resources to the CPS resources. The process of manually converting PD's science requirements from a simplified representation to a more complex CPS representation is a time-consuming and tedious process.
- THE GOAL: To provide a software solution to allow the planners to build a mapping of the complex CPS constraints to the basic URC constraints and automatically convert the PD's requirements into systems requirements during export to CPS.

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Constraints

- The term constraint is used to represent both resources and conditions.
  - Resources, such as power, have an availability of some amount over time.
  - Conditions have availabilities defined in binary terms and may be used concurrently by an unlimited number of activities. (e.g., TDRS availability)
  - Constraint types include general, condition, video, data, crew, water/Gas, photo, power/Thermal, vacuum, and commanding
- Two Different Constraints
  - URC constraints
    - Defined by the payload planner in the User Requirements Integration (URI) and are highly simplified
    - Payload Developers select the URC constraints in User Requirements Collection (URC) while building his activities.
  - CPS constraints
    - Defined by the planning community in the CPS and are used during timeline development.

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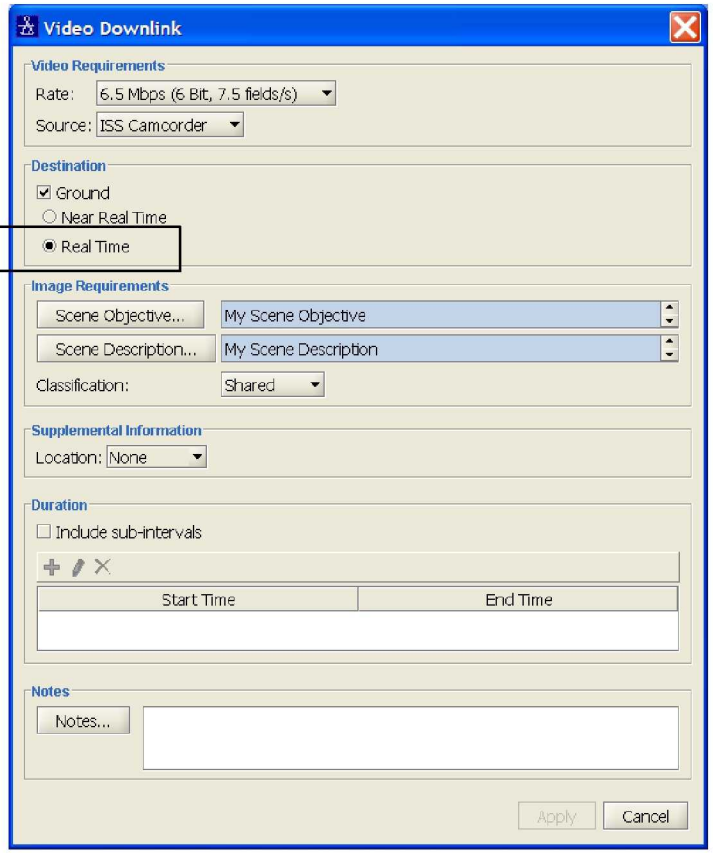
Constraint Representations

Complex System Constraint → Simplified URC Constraint

- Video Downlink in Real-Time
  - ISS DATA TOTAL – DIGITAL TOTAL
  - ISS DATA Video – Video System Total
  - ISS DATA Video – VSUx
  - ISS Data Video – HRFM VIDEO PORT
  - US SEG VIDEO EQUIP – LAB CAMCORDER
  - US SEGMENT DATA – RACK LAxx video port
  - ISS TDRS – ALL KU AVAIL



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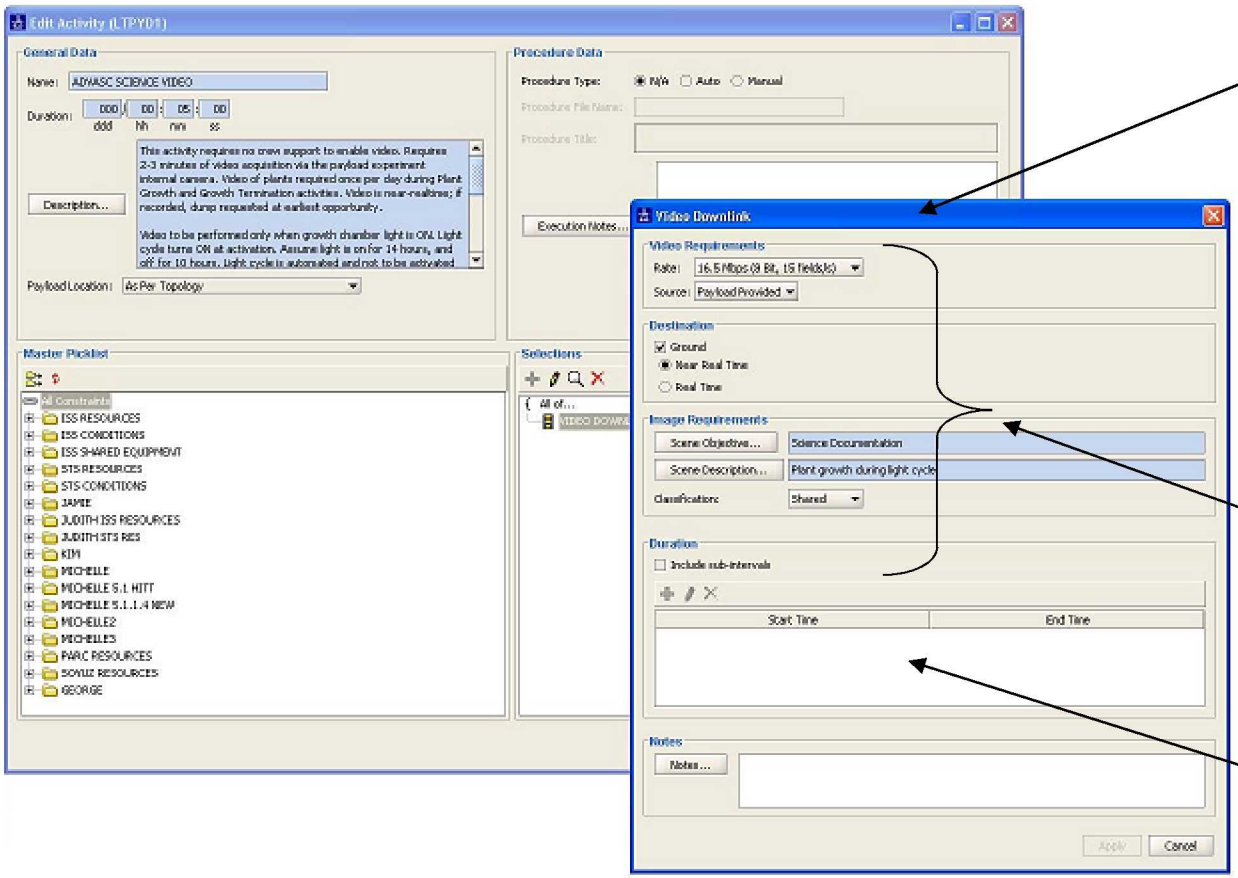
Activities

- Activities are typically developed by the payload developer to model a task to be performed (e.g., payload startup, experiment execution). Activities define
  - the applied constraints, i.e., resources quantities, durations and related attributes
  - the required duration of the activity
  - location of the activity
  - procedures to be executed

Sequences

- Sequences represent a collection of dependent tasks to be performed as a unit to meet a science objective.
- Sequences define the temporal relationships between the members of the sequence and the execution windows.
- Sequence members may be activities or other sequences.

Activity

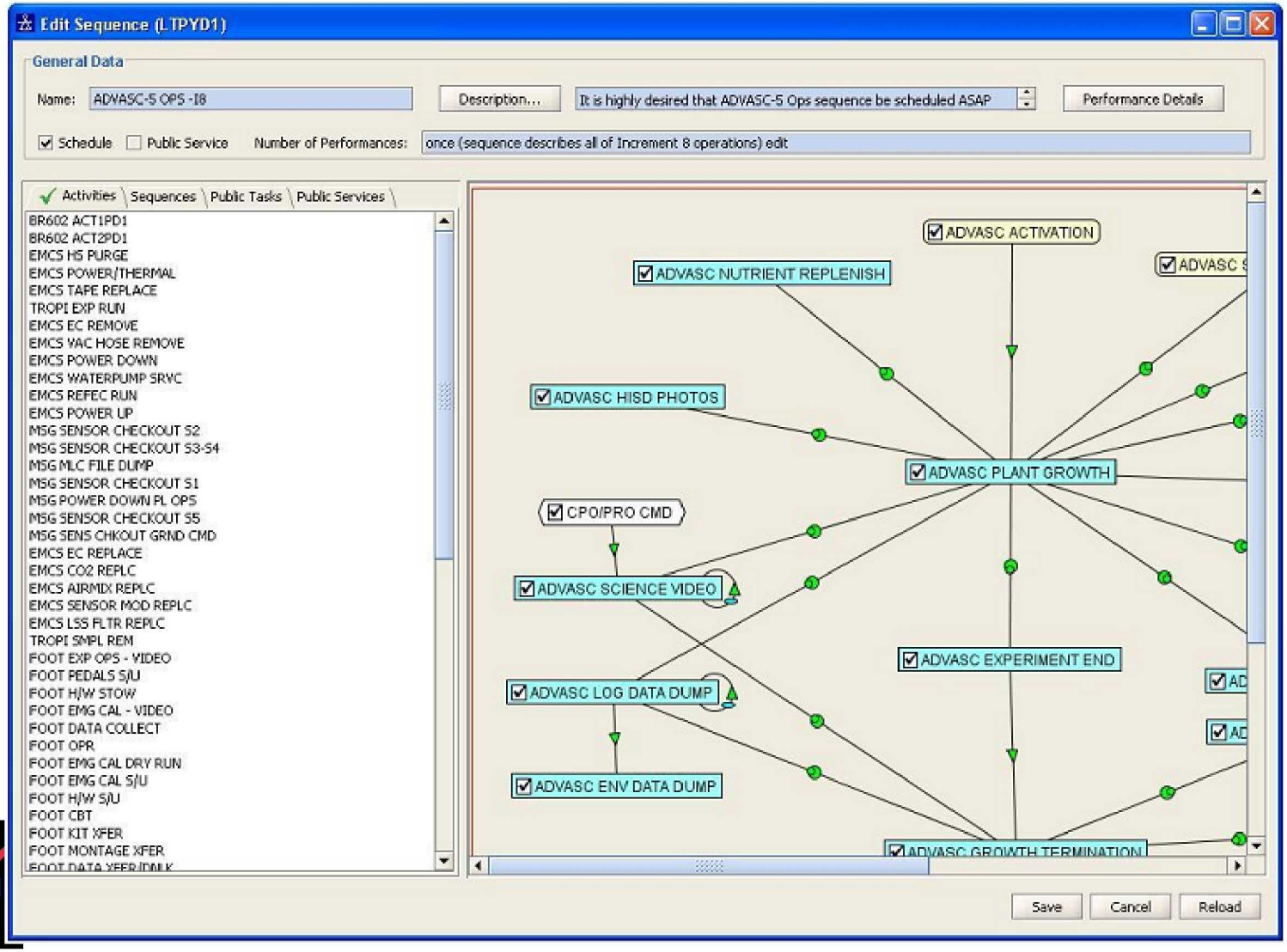


Applied Constraint

Attribute selections

Time Intervals

Sequence


Edit Sequence (LTPYD1)
General Data
Name: ADVASC-5 OPS -I8
Description...
It is highly desired that ADVASC-5 Ops sequence be scheduled ASAP
Performance Details
Schedule
Public Service
Number of Performances:
once (sequence describes all of Increment 8 operations) edit
Activities
Sequences
Public Tasks
Public Services
BR602 ACT1PD1
BR602 ACT2PD1
EMCS HS PURGE
EMCS POWER/THERMAL
EMCS TAPE REPLACE
TROPI EXP RUN
EMCS EC REMOVE
EMCS VAC HOSE REMOVE
EMCS POWER DOWN
EMCS WATERPUMP SRVC
EMCS REFEC RUN
EMCS POWER UP
MSG SENSOR CHECKOUT S2
MSG SENSOR CHECKOUT S3-S4
MSG MLC FILE DUMP
MSG SENSOR CHECKOUT S1
MSG POWER DOWN PL OPS
MSG SENSOR CHECKOUT S5
MSG SENS CHKOUT GRND CMD
EMCS EC REPLACE
EMCS CO2 REPLC
EMCS AIRMIX REPLC
EMCS SENSOR MOD REPLC
EMCS LSS FLTR REPLC
TROPI SMPL REM
FOOT EXP OPS - VIDEO
FOOT PEDALS S/U
FOOT H/W STOW
FOOT EMG CAL - VIDEO
FOOT DATA COLLECT
FOOT OPR
FOOT EMG CAL DRY RUN
FOOT EMG CAL S/U
FOOT H/W S/U
FOOT CBT
FOOT KIT XFER
FOOT MONTAGE XFER
ADVASC ACTIVATION
ADVASC NUTRIENT REPLENISH
ADVASC HISD PHOTOS
ADVASC PLANT GROWTH
CPO/PRO CMD
ADVASC SCIENCE VIDEO
ADVASC EXPERIMENT END
ADVASC LOG DATA DUMP
ADVASC ENV DATA DUMP
Save
Cancel
Reload

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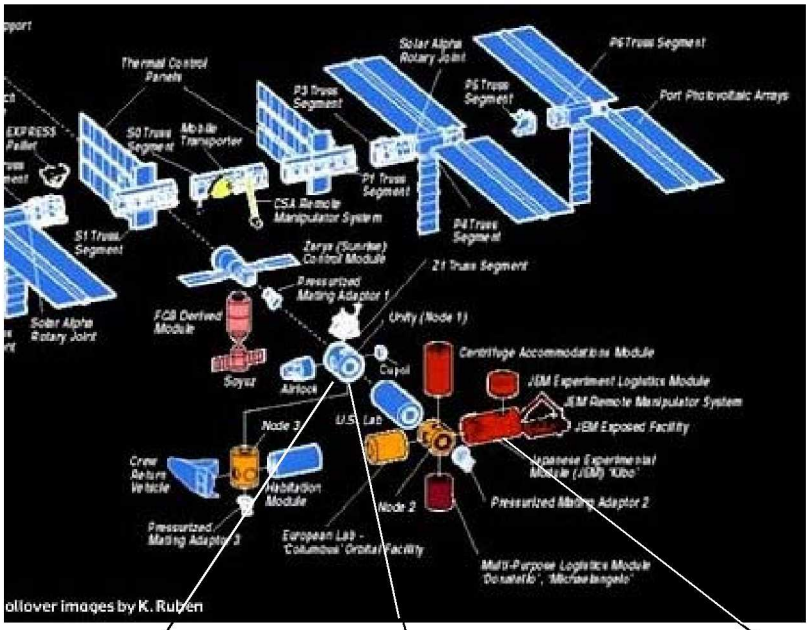
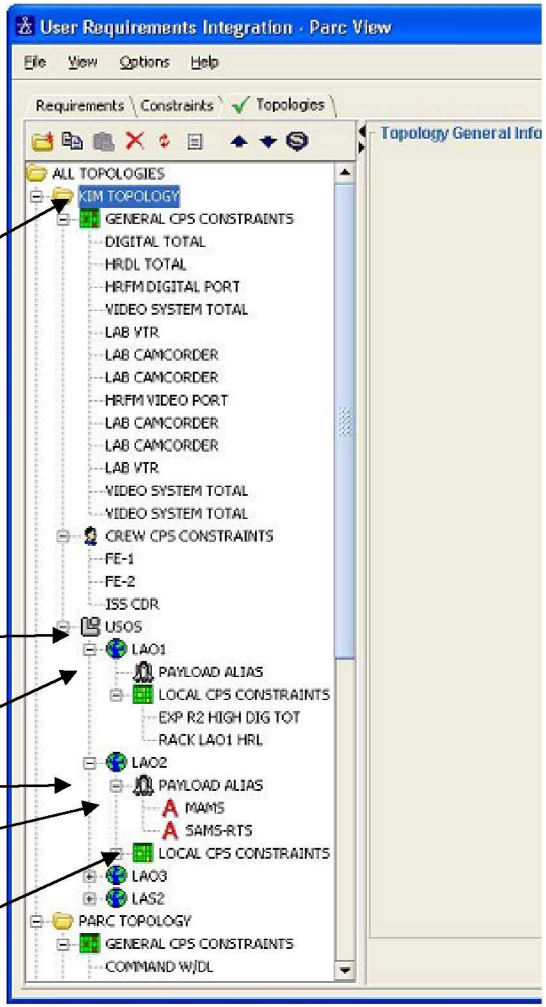
Increments and Topologies

- Increments
  - Increments are operational time periods defined by the beginning and ending of a crew rotation. When new crew members begin to operate the ISS, a new increment begins and the prior increment ends.
- Topologies
  - A URI topology is used to model the ISS configuration by modeling the payload rack locations for the purpose of assigning location specific ISS constraints.
  - Topologies can change due to new payloads, terminated payloads, or system re-configurations.
  - Topologies are assigned to an increment and be assigned to many increments.
  - Topologies in URI are defined by creating segments (e.g., USOS) and assigning rack locations to those segments.
  - Payload aliases are assigned to the topology locations.
    - Payload aliases allow the a convenient way to assign location, crew, and CPS specific attributes to a group of activities.

Topology



Topology

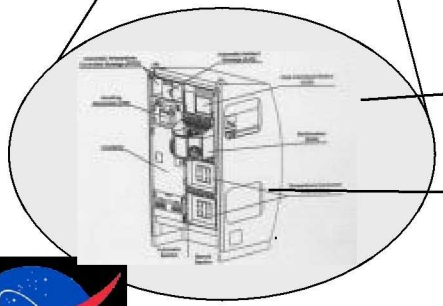


Segment

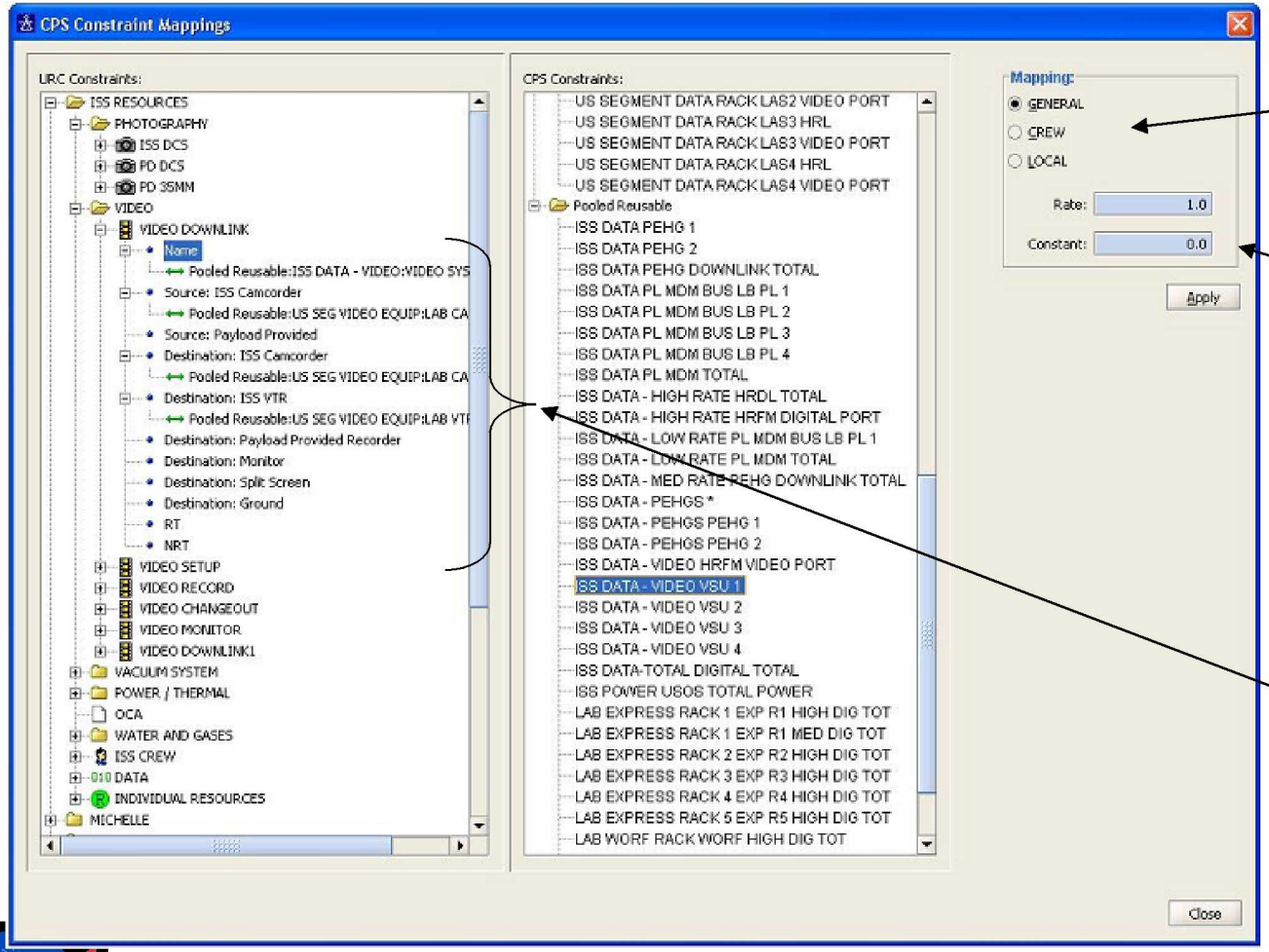
Locations

Payloads Aliases

Local Constraints



Constraint Mapping



Mapping Type

Relationship Function

Mappings of CPS Constraints to URC Constraint Attributes

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Constraint Mappings

- Constraint mappings are relationships (many-to-many) defined between URC constraints and CPS constraints.
- Constraint mappings are assigned to a specific topology
- Constraint mappings can define a linear relationship to be applied on export to the URC resource requirement to determine the appropriate amount of the CPS resource. This capability is useful in cases where the desired CPS constraint has different units of measure that the URC constraint.
- Constraint mappings can be one of three types:
  - General - applied to the activity regardless of location
  - Location specific – must be resolved using the location of the activity and the CPS constraints that are assigned to that location
  - Crew – a crew member aboard the ISS. Crew assignments are defined in the payload alias

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Timeline

- Timeline is the result of scheduling the activities and sequences in a manner which results in a plan for conflict-free execution of required events and ensures availability of required resources for each activity.
- In a timeline, each activity and sequence is assigned a fixed start time and stop time.
- Timelines are developed in CPS

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Operations Concept

Planners

Model the ISS topology for an increment

Develop increment specific attributes

Import CPS constraints into URC

Using the topology, map URC constraints to CPS constraints

Develop simplified constraints in URC

Planners assign payload aliases and define CPS specific attributes

Planners export URC activities and sequences to CPS

- Export uses the increment to gather the applicable constraint mappings and increment-specific data
- Export uses the constraint mappings to resolve the URC constraints into CPS constraints for each activity

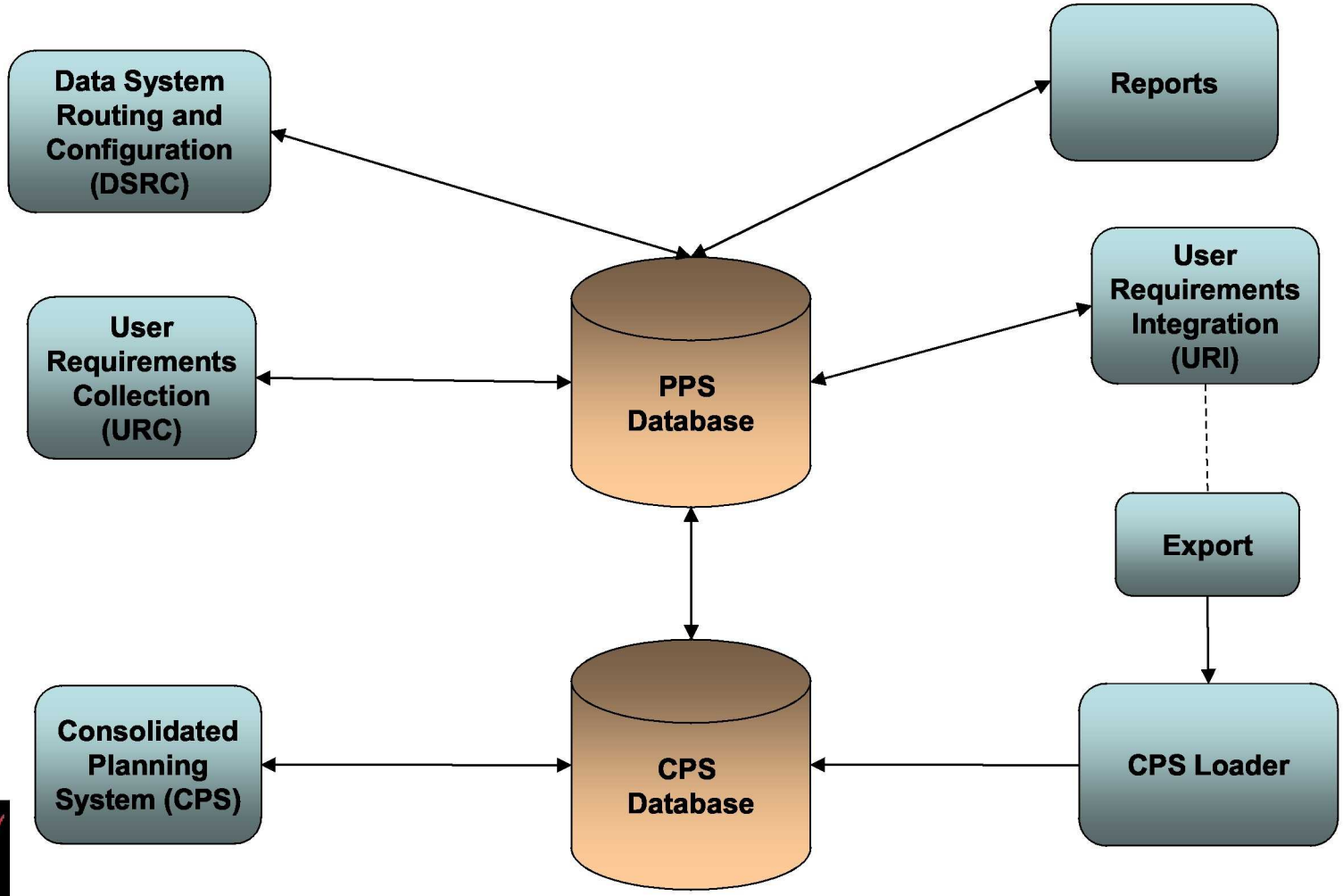
Payload Developers

Create activities and sequences

- Define applied constraints from simplified URC constraints

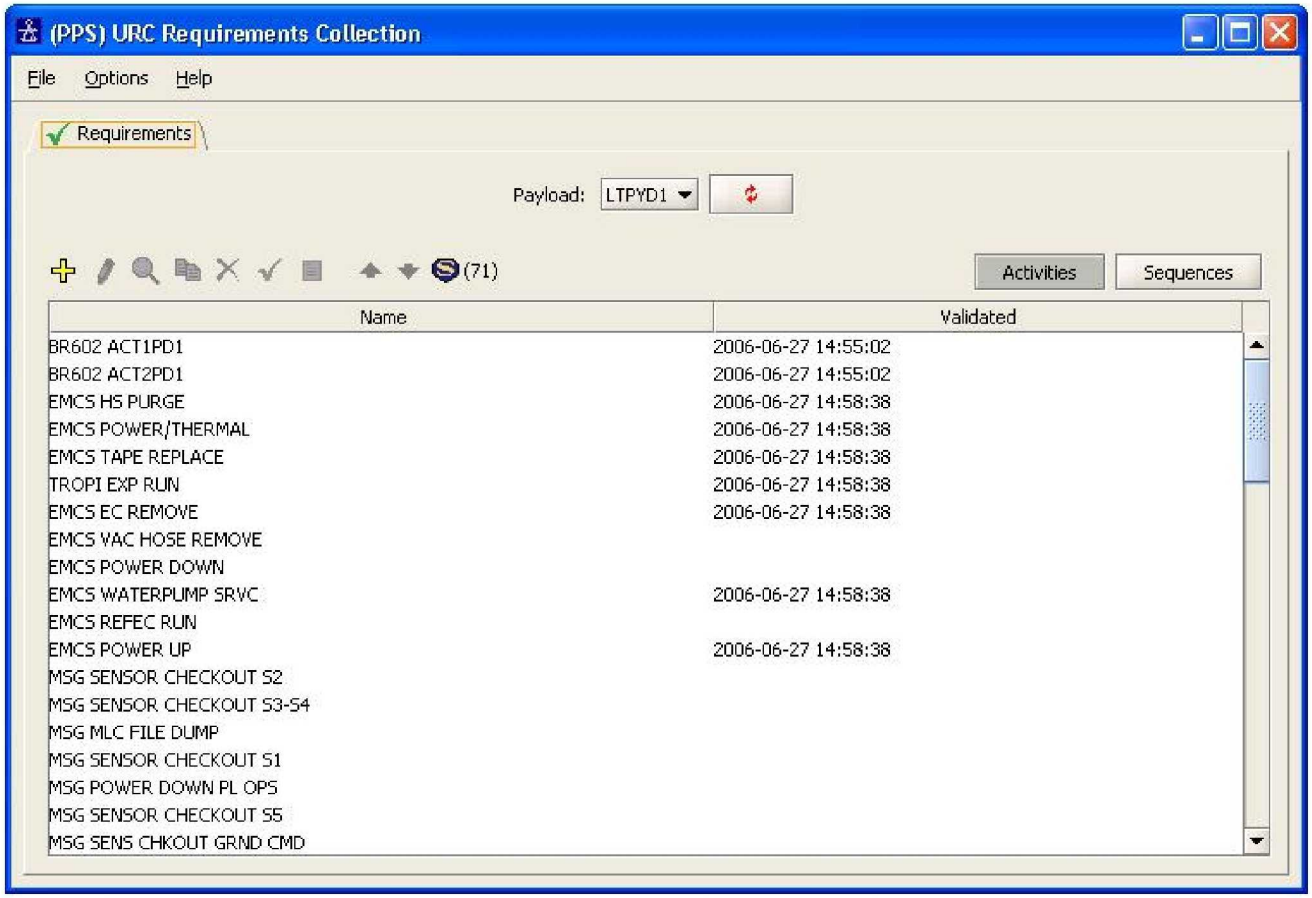
Submit completed activities and sequences to the POIC

Payload Planning System Overview



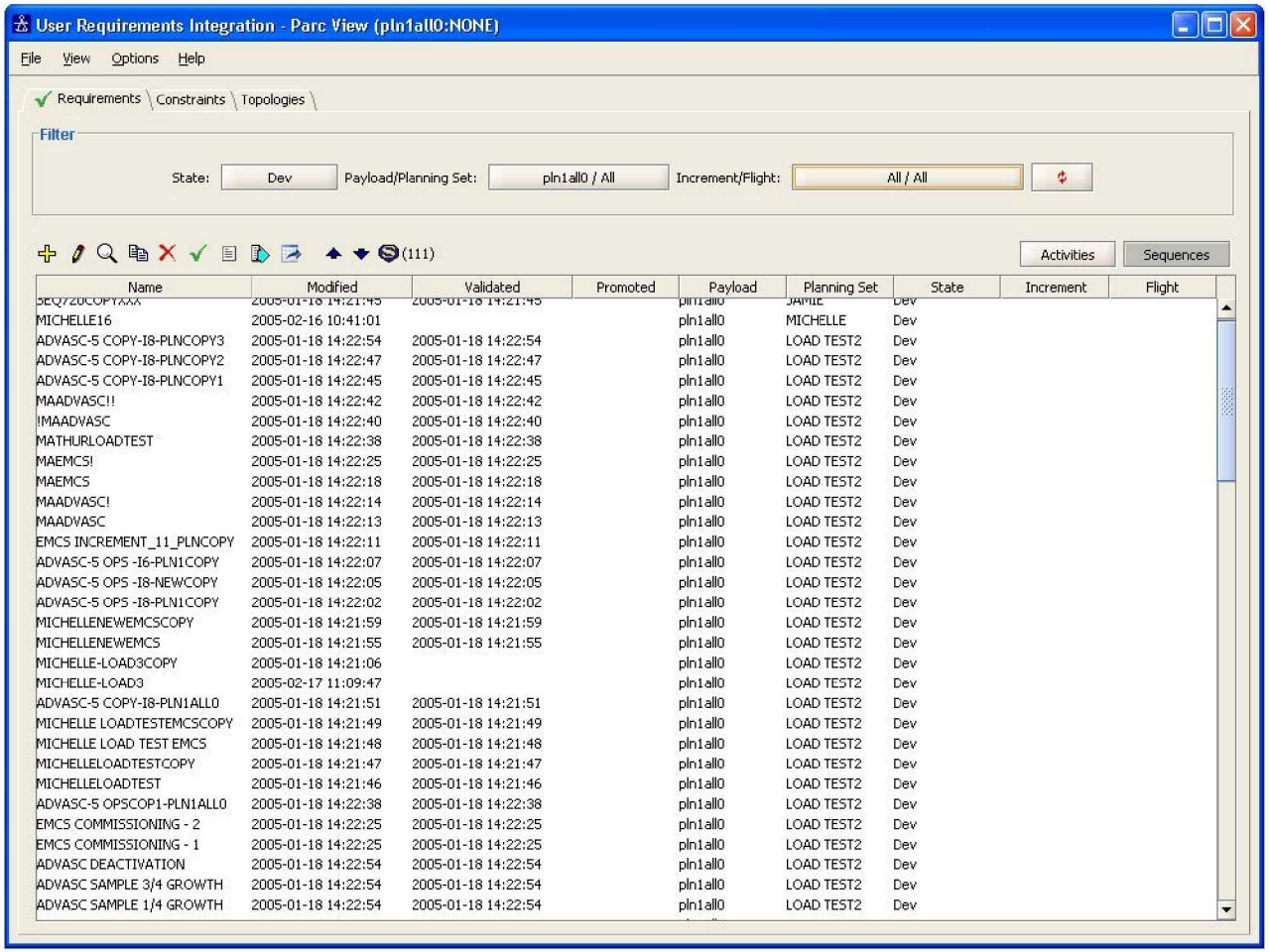
User Requirements Collection

- Used by PDs for the following tasks:
  - Model Activities
  - Model Sequences
  - Submit requirements to the POIC for scheduling
  - Generate reports



User Requirements Integration

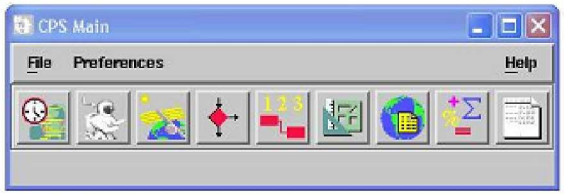
- Used by Planners and Planners for the following tasks:
  - Model constraints
  - Model topologies
  - Setup Increment-specific data
  - Create constraint mappings
  - Manage and access PD's activities and sequences
  - Export to CPS
  - Generate reports

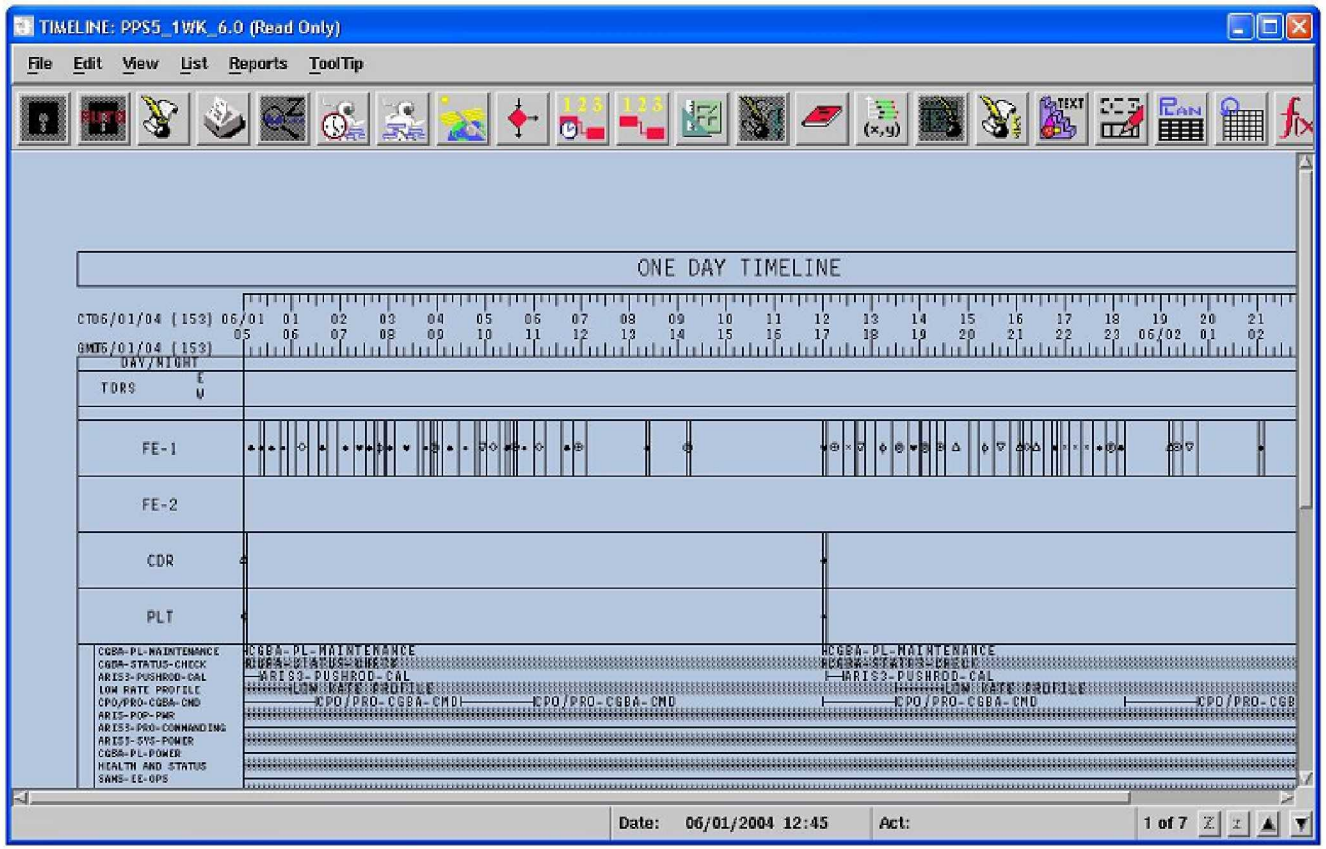


Name	Modified	Validated	Promoted	Payload	Planning Set	State	Increment	Flight
MICHELLE16	2005-02-16 10:41:01			pln1all0	MICHELLE	Dev		
ADVASC-5 COPY-I8-PLNCOPY3	2005-01-18 14:22:54	2005-01-18 14:22:54		pln1all0	LOAD TEST2	Dev		
ADVASC-5 COPY-I8-PLNCOPY2	2005-01-18 14:22:47	2005-01-18 14:22:47		pln1all0	LOAD TEST2	Dev		
ADVASC-5 COPY-I8-PLNCOPY1	2005-01-18 14:22:45	2005-01-18 14:22:45		pln1all0	LOAD TEST2	Dev		
MAADVASC!!	2005-01-18 14:22:42	2005-01-18 14:22:42		pln1all0	LOAD TEST2	Dev		
!MAADVASC	2005-01-18 14:22:40	2005-01-18 14:22:40		pln1all0	LOAD TEST2	Dev		
MATHURLOADTEST	2005-01-18 14:22:38	2005-01-18 14:22:38		pln1all0	LOAD TEST2	Dev		
MAEMCS!	2005-01-18 14:22:25	2005-01-18 14:22:25		pln1all0	LOAD TEST2	Dev		
MAEMCS	2005-01-18 14:22:18	2005-01-18 14:22:18		pln1all0	LOAD TEST2	Dev		
MAADVASC!	2005-01-18 14:22:14	2005-01-18 14:22:14		pln1all0	LOAD TEST2	Dev		
MAADVASC	2005-01-18 14:22:13	2005-01-18 14:22:13		pln1all0	LOAD TEST2	Dev		
EMCS INCREMENT_11_PLNCOPY	2005-01-18 14:22:11	2005-01-18 14:22:11		pln1all0	LOAD TEST2	Dev		
ADVASC-5 OPS -I6-PLN1COPY	2005-01-18 14:22:07	2005-01-18 14:22:07		pln1all0	LOAD TEST2	Dev		
ADVASC-5 OPS -I8-NEWCOPY	2005-01-18 14:22:05	2005-01-18 14:22:05		pln1all0	LOAD TEST2	Dev		
ADVASC-5 OPS -I8-PLN1COPY	2005-01-18 14:22:02	2005-01-18 14:22:02		pln1all0	LOAD TEST2	Dev		
MICHELLENEWEMCSCOPY	2005-01-18 14:21:59	2005-01-18 14:21:59		pln1all0	LOAD TEST2	Dev		
MICHELLENEWEMCS	2005-01-18 14:21:55	2005-01-18 14:21:55		pln1all0	LOAD TEST2	Dev		
MICHELLE-LOAD3COPY	2005-01-18 14:21:06			pln1all0	LOAD TEST2	Dev		
MICHELLE-LOAD3	2005-02-17 11:09:47			pln1all0	LOAD TEST2	Dev		
ADVASC-5 COPY-I8-PLN1ALL0	2005-01-18 14:21:51	2005-01-18 14:21:51		pln1all0	LOAD TEST2	Dev		
MICHELLE LOADTESTEMCSCOPY	2005-01-18 14:21:49	2005-01-18 14:21:49		pln1all0	LOAD TEST2	Dev		
MICHELLE LOAD TEST EMCS	2005-01-18 14:21:48	2005-01-18 14:21:48		pln1all0	LOAD TEST2	Dev		
MICHELLELOADTESTCOPY	2005-01-18 14:21:47	2005-01-18 14:21:47		pln1all0	LOAD TEST2	Dev		
MICHELLELOADTEST	2005-01-18 14:21:46	2005-01-18 14:21:46		pln1all0	LOAD TEST2	Dev		
ADVASC-5 OPSCOP1-PLN1ALL0	2005-01-18 14:22:38	2005-01-18 14:22:38		pln1all0	LOAD TEST2	Dev		
EMCS COMMISSIONING - 2	2005-01-18 14:22:25	2005-01-18 14:22:25		pln1all0	LOAD TEST2	Dev		
EMCS COMMISSIONING - 1	2005-01-18 14:22:25	2005-01-18 14:22:25		pln1all0	LOAD TEST2	Dev		
ADVASC DEACTIVATION	2005-01-18 14:22:54	2005-01-18 14:22:54		pln1all0	LOAD TEST2	Dev		
ADVASC SAMPLE 3/4 GROWTH	2005-01-18 14:22:54	2005-01-18 14:22:54		pln1all0	LOAD TEST2	Dev		
ADVASC SAMPLE 1/4 GROWTH	2005-01-18 14:22:54	2005-01-18 14:22:54		pln1all0	LOAD TEST2	Dev		

Consolidated Planning System

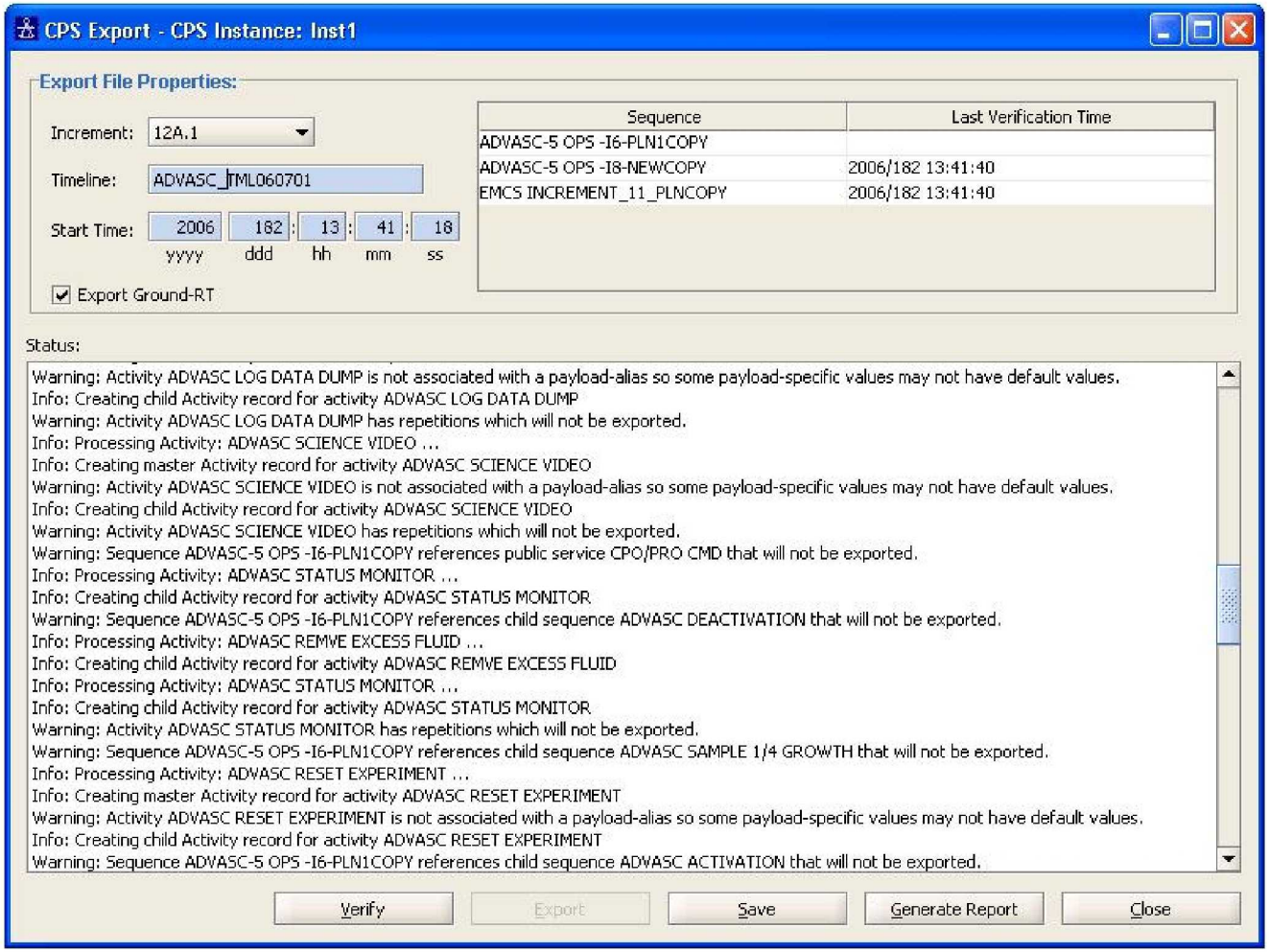
- Used by Planners and Planners to schedule payload activities and sequences
- Developed by JSC





Export Function

- Exports activities, sequences, and resources to CPS
- Uses the constraint mappings to resolve the URC constraints into CPS constraints for each activity
- Uses the increment to gather the applicable constraint mappings and increment-specific data



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Conclusions

- Using an automated process to convert payload developer science requirements from a simplified representation to a more complex representation required in the Consolidated Planning System (CPS)
  - Increases operational efficiency
  - Ensures reliable results
  - Provides payload developers a logical approach to modeling requirements.
  - Allows minimum changes by the payload developers to the activities and sequences when system re-configurations are made
- Analyzing operations processes can reveal innovative solutions that can produce cost, efficiency, and reliability benefits.
- Q & A

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